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ABSTRACT

The purpose of this experiment was to compare an inquiry-oriented Biological Sciences Curriculum Study (BSCS) style laboratory approach with a more directive traditional approach on student outcomes in the cognitive and affective domains of learning at two private, midwestern liberal arts colleges. Intact laboratory sections of students enrolled in introductory general biology were randomly selected into two treatment groups. Pretest and posttest measures were taken on three dependent variables: (1) biological content achievement; (2) reasoning ability; and (3) attitude toward biology. The experimental group using the BSCS-style laboratory approach scored significantly higher than the comparison group in levels of performance on biology content achievement. There were no significant differences between the two groups in performance levels on attitude toward biology or on reasoning ability. However, both groups experienced an increase in the number of formal thinkers as indicated by pretest-posttest gain scores on the reasoning ability test. These results lend support to the hypothesis that a BSCS-style laboratory approach fosters desired learner outcomes at the postsecondary level. In addition, these findings support the notion that the science laboratory may be used as a primary vehicle to promote formal reasoning skills. (Author/CW)

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A COMPARISON OF A BIOLOGICAL SCIENCES CURRICULUM STUDY (BSCS) LABORATORY AND A TRADITIONAL LABORATORY ON STUDENT ACHIEVEMENT AT TWO PRIVATE LIBERAL ARTS COLLEGES

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Abstract

The purpose of this experiment was to compare an inquiry-oriented Biological Sciences Curriculum Study (BSCS) style laboratory approach with a more directive traditional approach on student outcomes in the cognitive and affective domains of learning at two private, midwestern liberal arts colleges.

The BSCS approach emphasized basic and integrated science processes, concept development through extensive questioning, and increased student discretion, while the traditional approach contained highly structured, more prescriptive, teacher-oriented activites. Intact laboratory sections of students enrolled in introductory general biology at two private liberal arts colleges were randomly selected into two treatment groups. Pretest and posttest measures were taken on three dependent variables: (1) biological content achievement, measured with a researcher-generated Test on Biological Laboratory Concepts, (2) reasoning ability, measured with the Group Assessment of Logical Thinking, and (3) attitude toward biology, measured with the Biology Student Behavior Inventory. Analysis of covariance indicated the experimental group (n=60) using the BSCS-style laboratory approach scored

significantly higher than the comparison group (n=59) in levels of performance on biology content achievement, (F(1, 114) = 4.07, p<.05). There were no significant differences between the two groups in performance levels on attitude toward biology or on reasoning ability. However, both groups experienced a 15 percent increase in the number of formal thinkers as indicated by pretest-posttest gain scores on the reasoning ability test. These results lend support to the hypothesis that a BSCS-style laboratory approach fosters desired learner outcomes at the postsecondary level. In addition, these findings support the notion that the science laboratory may be used as a primary vehicle to promote formal reasoning skills.

A COMPARISON OF A BIOLOGICAL SCIENCES CURRICULUM STUDY (BSCS) LABORATORY AND A TRADITIONAL LABORATORY ON STUDENT ACHIEVEMENT AT TWO PRIVATE LIBERAL ARTS COLLEGES

Purpose

The purpose of this experiment was to compare an inquiry-oriented Biological Sciences Curriculum Study (BSCS) style laboratory approach with a more directive traditional laboratory approach on student outcomes in the cognitive and affective domains of learning at two private, midwestern liberal arts colleges. The BSCS approach placed emphasis on basic and integrated science processes, concept development through extensive questioning, and increased student discretion (Leonard, 1982) while the traditional approach contained highly structured, more prescriptive, teacher-oriented activities.

A recent study by Leonard (1983) at a large midwestern university generated evidence to support the notion that a BSCS-style, inquiry-oriented laboratory approach increased student biological conceptual learning compared to a more traditional approach. As such this college level material has potential to promote recognized science education goals including science process skills, independent thinking, and positive attitudes toward science.

In the research described in this paper, an experimental group used BSCS-style laboratory materials

and the group's performance on a Test on Biological Laboratory Concepts (TBLC) was compared to that of a group using more traditional laboratory materials. In addition, student reasoning abilities were measured and compared using a Group Assessment of Logical Thinking (GALT) test (Roadrangka, Yeany, & Padilla, 1983). Student outcomes in the affective domain were assessed and compared using a Biology Student Behavior Inventory (BSBI) which measured curiosity, satisfaction, openness, and responsibility (Steiner, 1970).

It was hypothesized that subjects using the BSCS-style laboratory learning approach would: (1) score no higher on a test of biological laboratory concepts, (2) score no higher on a test of logical thinking, or (3) show no significant differences in attitudes toward biology than subjects using a more directive, traditional laboratory approach. Only recently has a BSCS-style laboratory approach been developed, implemented, and evaluated for use in an introductory general biology course at the postsecondary level (Leonard, 1983). This present study attempted to provide additional evidence in support of the generalizability of a BSCS-style approach for use in colleges or universities.

Theoretical Base

The new government funded science curricula of the 1960s and 1970s contributed much to the development of science education. Even though the use of these materials has recently slowed, the philosophies and strategies remain sound. For instance, a meta-analysis by Shymansky (1984) on the effectiveness of these curricula suggested that learners performed better in achievement, attitude, process, and analytic skills than did their counterparts using a more traditional format. The BSCS biology program in particular showed the greatest margin of effectiveness across performance measures.

Despite the apparent effectiveness of the BSCS program, very few colleges and universities pattern their introductory science programs after the inquiry approach. Research indicates most undergraduate university science courses are fact-laden, non-inquiry oriented with cookbook-like laboratories which negate the learning of science process skills and inquiry learning (Kyle, Penick & Shymansky, 1979). Given that teachers tend to teach according to how they were taught, it is not surprising that many preservice and inservice teachers have biased views about science processes and inquiry teaching.

Inquiry-oriented science laboratory instruction emphasizing active participation with concrete

materials and "hands-on" experiences may provide opportunities to enhance formal reasoning abilities (Karplus, 1977; Kolodiy, 1977; Renner & Lawson, 1973). Furthermore a recent study by Yeany, Yap and Padilla (1986) reported findings that suggest an educationally important relationship may exist between student cognitive development based upon Piagetian developmental psychology and science process skills as defined by science educators. These findings could have important implications in promoting advanced reasoning patterns in learners.

Research in science education over the past several years has collected evidence to suggest that many adolescents and young adults are not able to apply abstract reasoning (Chiappetta, 1976; Lawson & Renner, 1975). As many as 50 percent of those college students tested show reasoning abilities below the Piagetian formal operational developmental stage. As a result, these concrete operational students cannot understand abstract science concepts such as "gene", "chemical bond", and "ideal gas", nor can they effectively solve Mendelian genetics problems and comprehend abstract instructional procedures such as lecture and science textbook reading assignments (Haley & Good, 1976; Gipson & Abraham, 1985; Karplus, 1977).

Thus, it appears that science educators need to modify course materials and to develop teaching

strategies to better fit the needs of those students deemed concrete operational and to help them to become formal thinkers. The science laboratory may be used as a vehicle for developing advanced reasoning patterns, particularly if one uses a "hands-on", investigative, inquiry approach with emphasis on science processes and active student participation such as that advocated by the BSCS-style laboratory approach.

Cognitive domain research continues to dominate the science literature. There is a clear need to identify important variables in the affective domain and to accurately test and to evaluate these variables in terms of student laboratory behaviors (Hofstein & Lunetta, 1982). Continued declines in science interest beginning at grades four and continuing on through college pose serious concerns for science educators (Yager & Penick, 1986). Teacher education programs and science programs in general apparently are not emphasizing activities to promote positive science attitudes. Promoting interest in science at the college level should be a prime objective, particularly if students taking introductory science courses later become elementary teachers. These teachers could be especially affected by negative attitudes toward science, which in turn could carry over to their students. Inquiry-oriented, student centered

laboratory activities appear to have promise in promoting positive attitudes toward science.

Procedure

This experiment was conducted during the 1986 Fall Semester using 119 subjects from introductory general biology courses at two private midwestern liberal arts colleges. The experimental (BSCS) group totaled 60 subjects while the comparison (traditional) group totaled 59 subjects. Subjects were heterogeneous with respect to ability level, prior science experiences, and socioeconomic background. Most subjects were the age of typical college freshmen and sophomores.

Subjects self-assigned to their respective laboratory sections. These intact sections were then randomly assigned into two treatment groups. Thus, the design was quasi-experimental nonequivalent control groups with pretest-posttest. Independent variables were method of laboratory instruction and laboratory setting; dependent variables were (1) a 63-item researcher-generated multiple-choice Test on Biology Laboratory Concepts, pretest-posttest; (2) a 12-item Group Assessment of Logical Thinking, prestest-posttest; and (3) a Biology Student Behavior Inventory, pretest-posttest. A total of 12 laboratory activities from the BSCS-style were selected and matched in concept but not in method with each of the 12 traditional investigations. All subjects participated

in one, two-hour laboratory for each of 15 weeks of the semester in addition to the separate lectures.

Three pretests were administered at the beginning of the semester and the same tests were administered as posttests after 13 weeks of laboratory instruction. Whenever appropriate, repeated measure analysis of covariance (ANCOVA) procedures were applied to each posttest measure using pretest scores as covariates. The data were then subjected to a two-way ANCOVA. Where homogeneity of regression slopes was violated, analysis of variance (ANOVA) was used. Since a prime concern was to avoid making a type II error, a significance level of .10 was established prior to statistical analysis.

Results

Adjusted posttest means from scores on the Test on Biological Laboratory Concepts showed no significant differences between settings, $F(1, 114) = .01$, $p = .93$. However, significant differences were found in favor of the experimental group in levels of performance on biology laboratory content achievement ($F(1, 114) = 4.07$, $p<.05$.

Adjusted posttest means from scores on the Group Assessment of Logical Thinking showed no significant differences between settings, $F(1, 114) = .45$, $p = .51$, or between groups, $F(1, 114) = .86$, $p = .36$. However, the number of formal thinkers in both groups increased

from 47 to 65 during this study as indicated by pretest-posttest gain scores, an increase of 15 percent.

Analysis of variance using scores on the Biology Student Behavior Inventory showed no significant differences between settings, $F(1, 114) = .59$, $p = .45$, or between groups, $F(1, 114) = 1.54$, $p = .22$.

Conclusions:

(1) This study generated evidence to support the idea that a BSCS-style laboratory approach in introductory biology courses at two private liberal arts colleges was significantly more effective in promoting learning of biological laboratory concepts than a more traditional directive approach as measured by a Test on Biological Laboratory Concepts. These results lend support to the recent findings reported by Leonard (1983) as well as to past research studies reported by Shymansky (1984) showing that an inquiry-oriented laboratory patterned after the BSCS approach fosters important learner outcomes.

(2) There were no significant differences in logical thinking gain scores between subjects using a BSCS-style laboratory approach and those subjects using a more traditional laboratory approach as measured by a Group Assessment of Logical Thinking test. However, there appeared to be a tendency toward moving subjects from both groups out of the concrete operational

reasoning mode and into the formal operational reasoning mode following a period of 13 weeks of laboratory instruction. These results support the general findings of several research studies including Renner and Lawson (1973), Karplus (1977) and Bates (1978) that the science laboratory may be utilized as a primary vehicle to promote formal reasoning.

(3) No significant differences in attitudes toward biology were found between subjects using a BSCS-style laboratory approach and those subjects using a more traditional laboratory approach as measured by a Biology Student Behavior Inventory. In general, educational research has produced inconclusive evidence as to the extent science laboratories promote positive science attitudes among learners.

Implications

1. Science educators should continue to promote BSCS-style laboratory learning at all grade levels, particularly at the postsecondary level.
2. Students need opportunities to handle concrete materials in an inquiry-oriented laboratory setting prior to more abstract instructional modes.
3. Educators in general must recognize that a large percentage of secondary and postsecondary students are unable to use formal reasoning skills.
4. Students should be provided with a variety of instructional materials and activities appropriate for their particular reasoning level.
5. Assisting students to use higher level cognitive processes should be a primary educational objective in learning experiences across all disciplines and at all age levels.
6. Science laboratories may be used as a primary vehicle to promote formal reasoning skills.
7. Student learning outcomes in the affective domain have been neglected in many science laboratories despite their recognized importance by science educators.

Literature Cited

Bates, G. C. (1978). The role of the laboratory in secondary school science programs. In M. B. Rowe (Ed.), What research says to the science teacher, (Vol. 1). National Science Teachers Association.

Chiappetta, E. L. (1976). A review of Piagetian studies relevant to science instruction at the secondary and college level. Science Education, 60, 253-261.

Gipson, M., & Abraham, M. (1985, April). Relationships between formal-operational thought and conceptual difficulties in genetics problem solving. Paper presented at the Annual Meeting of the National Association for Research in Science Teaching, French Lick Springs, IN.

Haley, S. B., & Good, R. G. (1976). Concrete and formal operational thought: Implications for introductory college biology. The American Biology Teacher, 38, 407-412, 430.

Hofstein, A., & Lunetta, V. N. (1982). The role of the laboratory in science teaching: Neglected aspects of research. Review of Educational Research, 52, 201-217.

Karplus, R. (1977). Science teaching and the development of reasoning. Journal of Research in Science Teaching, 14, 169-175.

Kolodiy, G. (1977). Cognitive development and science teaching. Journal of Research in Science Teaching, 14, 21-26.

Kyle, W. C., Jr., Penick, J. E., & Shymansky, J. A. (1979). Assessing and analyzing the performance of students in college science laboratories. Journal of Research in Science Teaching, 16, 545-551.

Lawson, A. E., & Renner, J. W. (1975). Relationship of science subject matter and developmental levels of learners. Journal of Research in Science Teaching, 12, 347-358.

Leonard, W. H. (1982). Laboratory investigations in biology. Minneapolis: Burgess Publishing Co.

Leonard, W. H. (1983). An experimental study of a BSCS-style laboratory approach for university general biology. Journal of Research in Science Teaching, 20, 807-813.

Renner, J. W., & Lawson, A. E. (1973). Promoting intellectual development through science teaching. The Physics Teacher, 11, 273-276.

Roadrangka, V., Yeany, R. H., & Padilla, M. J. (1983, April). The construction and validation of group assessment of logical thinking (Galt). Paper presented at the annual meeting of the National Association for Research in Science Teaching, Dallas, TX.

Shymansky, J. (1984). BSCS programs: Just how effective were they? The American Biology Teacher, 46, 54-57.

Steiner, H. E., Jr. (1970). Biology student behavior inventory. Unpublished test, University of South Florida, College of Education, Tampa, FL.

Yager, R. E., & Penick, J. E. (1986). Perceptions of four age groups toward science classes, teachers, and the value of science. Science Education, 70, 355-363.

Yeany, R. H., Yap, K. C., & Padilla, M. J. (1986). Analyzing hierarchical relationships among modes of cognitive reasoning and integrated science process skills. Journal of Research in Science Teaching, 23, 277-291.